

Patent Claims

1. Piezoelectrical device in a monolithic multilayer form with a stack of at least two ceramic layers and an electrode layer set in between two ceramic layers, where the electrode layer contains copper.
2. Device according to claim 1, which is produced from ceramic green foils, which contain a thermohydrolithically degradable binder.
3. Device according to claim 2, where the binder is a polyurethane dispersion.
4. Device according to one of the claims 1 to 3, where the density of the ceramic layers shows at least 96% of the theoretically obtainable density.
5. Device according to one of the claims 1 to 4, where the ceramic layers contain grains with a grain size between 0,8 and 5 μm .
6. Device according to one of the claims 1 to 5, which includes at least 10 stacked electrode layers.
7. Device according to one of the claims 1 to 6, where the ceramic layers contain a ferroelectrical Perovskite-ceramic with the general composition ABO_3 .
8. Device according to claim 7, where the Perovskite-ceramic is of the PZT type $\text{Pb}(\text{Zr}_x\text{Ti}_{1-x})\text{O}_3$.
9. Device according to claim 7 or 8, where cations are built in on A-positions of the ceramic, and where cations on B-positions are replaced by apt other cations or combinations of cations.
10. Device according to claim 9, where bivalent metal cations M^{II} are built in on A-positions of the ceramic.
11. Device according to claim 10, where the bivalent metal cations M^{II} are selected from a group of elements, which contains barium, strontium, calcium and copper.
12. Device according to claim 10, where partially trivalent metal cations M^{III} are built in on the A-positions of the ceramic, which are selected from a group of elements containing scandium, yttrium, bismuth and lanthanum or from the group of the lanthanides.
13. Device according to claim 10, where monovalent cations are integrated on A-positions of the ceramic.
14. Device according to claim 13, where the monovalent cations are selected from a group of elements containing silver,

copper, sodium and potassium.

15. Device according to claim 10 and 14,
where combinations of bivalent metal cations M^{II} and monovalent cations are integrated on A-positions of the ceramic.
16. Device according to claim 8,
where for the partial substitution of the quadrivalent cations Zr and Ti on the B-positions of the ferroelectrical Perovskite ceramic combinations of mono- and quinvalent metal cations $MI1/4MV3/4$ with $MI = Na, K$ and $MV = Nb, Ta$ or bi- and quintvalent metal cations $MII1/3MV2/3$ with $MII = Mg, Zn, Ni, Co$ and $MV = Nb, Ta$ or tri- and quintvalent metal cations $MIII1/2MV2/3$ with $MIII = Fe, In, Sc$, heavier lanthanide elements and $MV = Nb, Ta$ or combinations $MIII2/3MVI1/3$ with $MIII = Fe, In, Sc$, heavier lanthanide elements and $MVI = W$ or $MII1/2MVI1/2$ with $MII = Mg, Co, Ni$ and $MVI = W$ are used.
17. Device according to claim 9,
where the composition of the general formula $Pb1-x-ySExCuyV''' X/2(Zr0,54-zTi0,46+z)O3$ corresponds with $0,01 < x < 0,05$ and $=0,15 < z < +0,15$ as well as $0 < y < 0,06$, whereby SE is a rare earth metal and V is a vacancy, and whereby a PbO surplus from 1 to maximally 5 molar-% is set.
18. Device according to one of the claims 9 to 16,
where the ceramic contains an additive of CuO.
19. Method for the production of a device according to one of the claims 1 to 18 with the following steps:
 - a) Production of a stack of a ceramic green foil containing binder and electrode layers by stacking and added laminating of the green foils resp. electrode layers
 - b) Debinding of the stack in the atmosphere, which contains inert gas and oxygen, whereby the oxygen content is reduced by adding an apt amount of hydrogen or by gettering in such a way, that the electrode layers will not be damaged.
20. Method according to claim 19
whereby the debinding is carried out at a temperature between 150 and 600°C.
21. Method according to claim 19 or 20,
whereby the used atmosphere for the debinding shows hydrogen with a partial pressure > 200 mbar.
22. Method according to one of the claims 19 to 21,
whereby the layered stack is sintered after the debinding at a temperature, which is lower than the melting point of copper, whereby an atmosphere is used for the sintering, which contains nitrogen, hydrogen and steam, and whereby the oxygen partial pressure is set by an apt hydrogen concentration in such a way, that the equilibrium partial pressure of the equilibrium $Cu/Cu2O$ is not exceeded.
23. Method according to claim 22,
whereby a maximal temperature for a duration between 2 and 12 hours is kept.

Summary

Piezoelectrical device and method for its production.

The invention concerns a piezoelectrical device, whose electrode layers contain copper. The usage of copper in the electrode layers is enabled by a debinding process, which is carried out by steam.